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Mosaics in Science - Summer 2013 Cohort

# Mapping streams and wetlands in Catoctin Mountain Park



*Moving water connects these places,  
weaving the threads of the landscape  
together. The places where water and land  
combine—the riparian zones—mediate  
these connections, and what happens in  
these zones affects areas far beyond their  
boundaries.*

– Nancy Langston,  
*Where Land and Water Meet*

# Outline

- Fundamentals
- Cultural history
- Lithology
- Watersheds and wetlands
- Data and results
- Applications



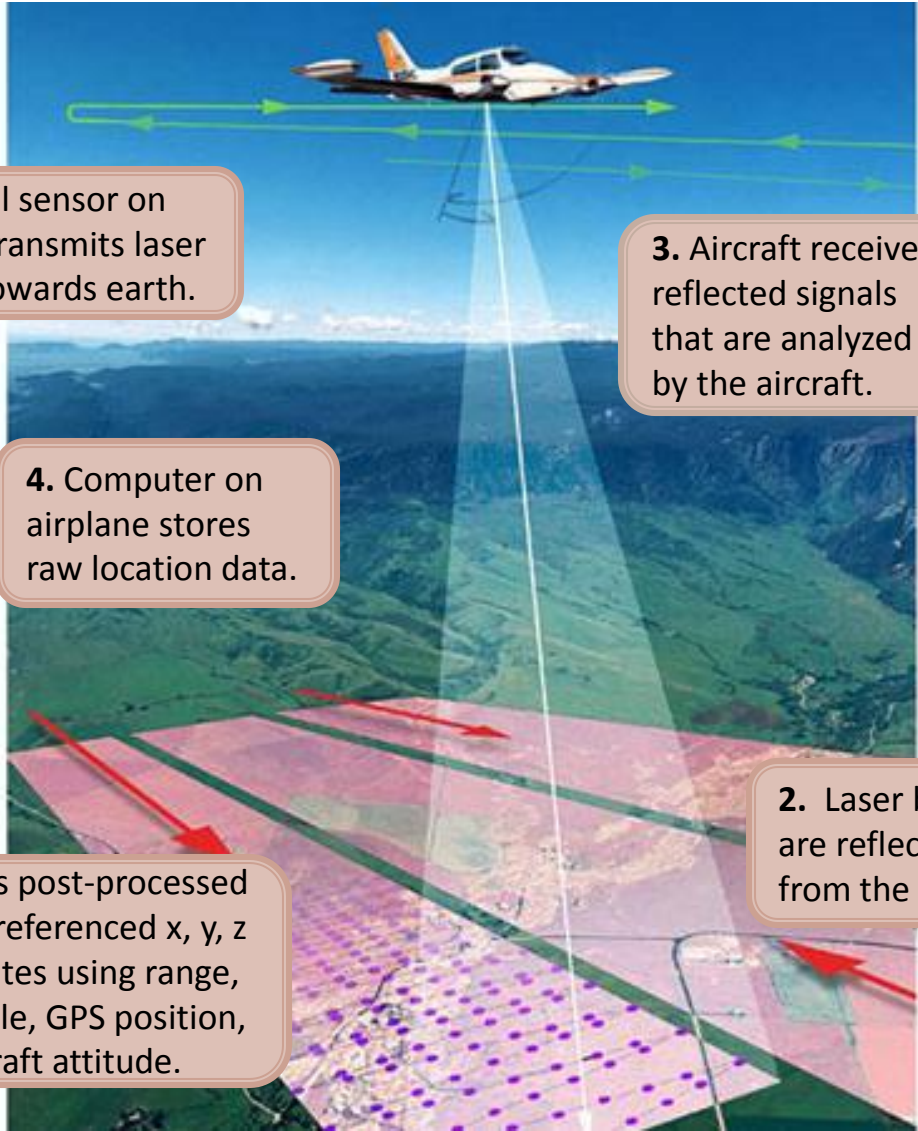
# Fundamentals of GIS

*What are LiDAR, GIS, and GPS? Why are these technologies useful for stream and wetland mapping in Catoctin Mountain Park?*



# Fundamentals: Introduction to LiDAR

LiDAR (**L**ight **D**etection and **R**anging) is an optical remote sensing technology based on distance measurements from the sensor to the target to provide accurate topographic data.



The diagram illustrates the LiDAR process from an aircraft. At the top, a small white aircraft is shown in flight against a blue sky. Green arrows indicate the aircraft's path and the scanning swath. A white laser beam is shown originating from the aircraft and pointing down towards a green, hilly landscape. At the bottom, a pinkish-red shaded area represents the ground surface, with a grid of purple dots indicating the collected data points. Red arrows point from the numbered text boxes to the corresponding parts of the diagram: Box 1 points to the aircraft, Box 2 points to the ground, Box 3 points to the aircraft, Box 4 points to the aircraft, and Box 5 points to the ground data grid.

**1.** Optical sensor on aircraft transmits laser beams towards earth.

**3.** Aircraft receives reflected signals that are analyzed by the aircraft.

**4.** Computer on airplane stores raw location data.

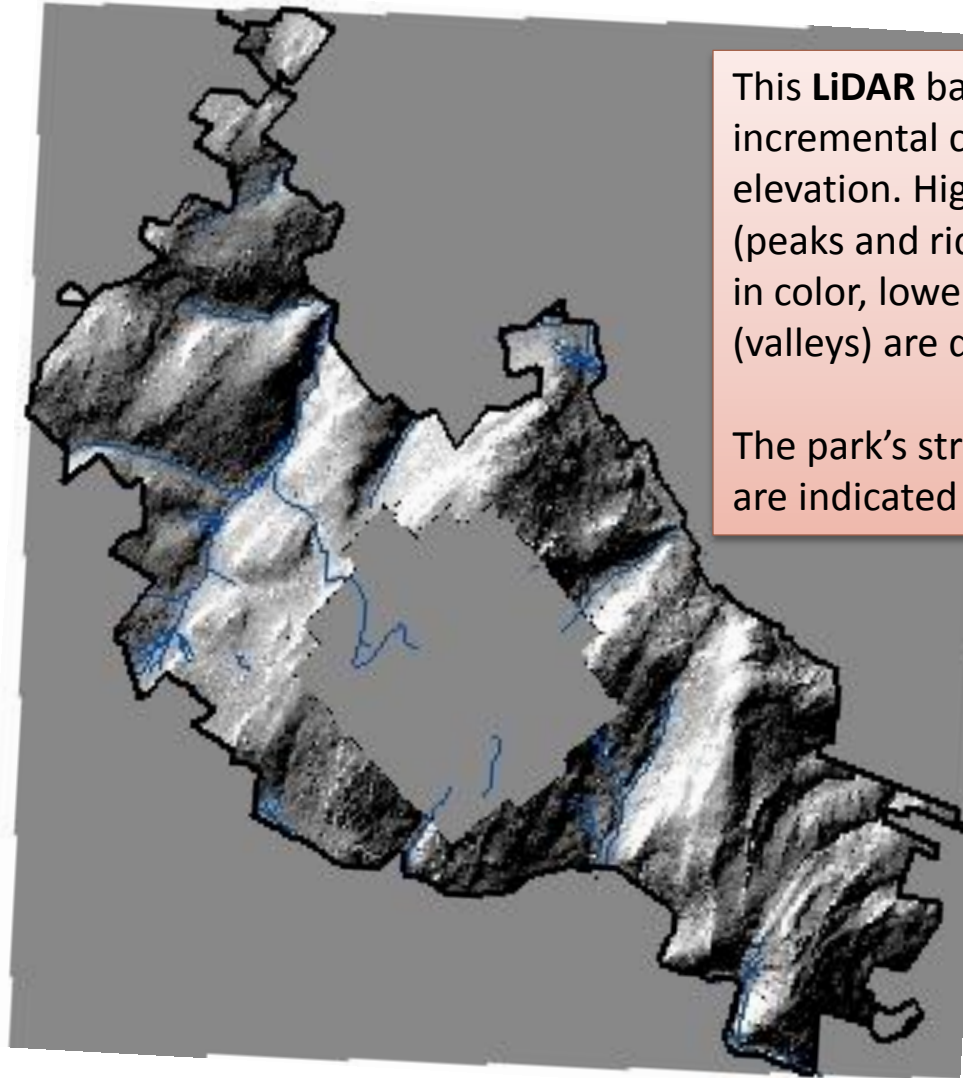
**2.** Laser beams are reflected from the ground.

**5.** Data is post-processed into georeferenced x, y, z coordinates using range, scan angle, GPS position, and aircraft attitude.

## Fundamentals: Introduction to LiDAR

LiDAR (**L**ight **D**etection **A**nd **R**anging) is an incredibly useful tool that, when used in conjunction with GIS, has endless applications.

In this project, LiDAR scans and aerial photos formed the project map's base layers in ArcGIS.



This **LiDAR** base layer shows incremental changes in elevation. Higher elevations (peaks and ridges) are lighter in color, lower elevations (valleys) are darker in color.

The park's streams and rivers are indicated in blue.

# Cultural History

*What is the relationship between Catoctin Mountain's cultural and natural histories?*



## Pre-Colonization Catoctin

Catoctin Mountain was an important source of metarhyolite for Native Americans which was mined for making arrowheads, hoes and other tools.

Humans crossed the Bering Strait land bridge during the Paleo-Indian Area (1300-7500 BC) , and nomadic hunters have left traces of their temporary establishments in Maryland.

However, most indigenous tribes and villages in the area were established after the climate warmed and spurred the development of agriculture (between 2000 BC – 1600 AD).

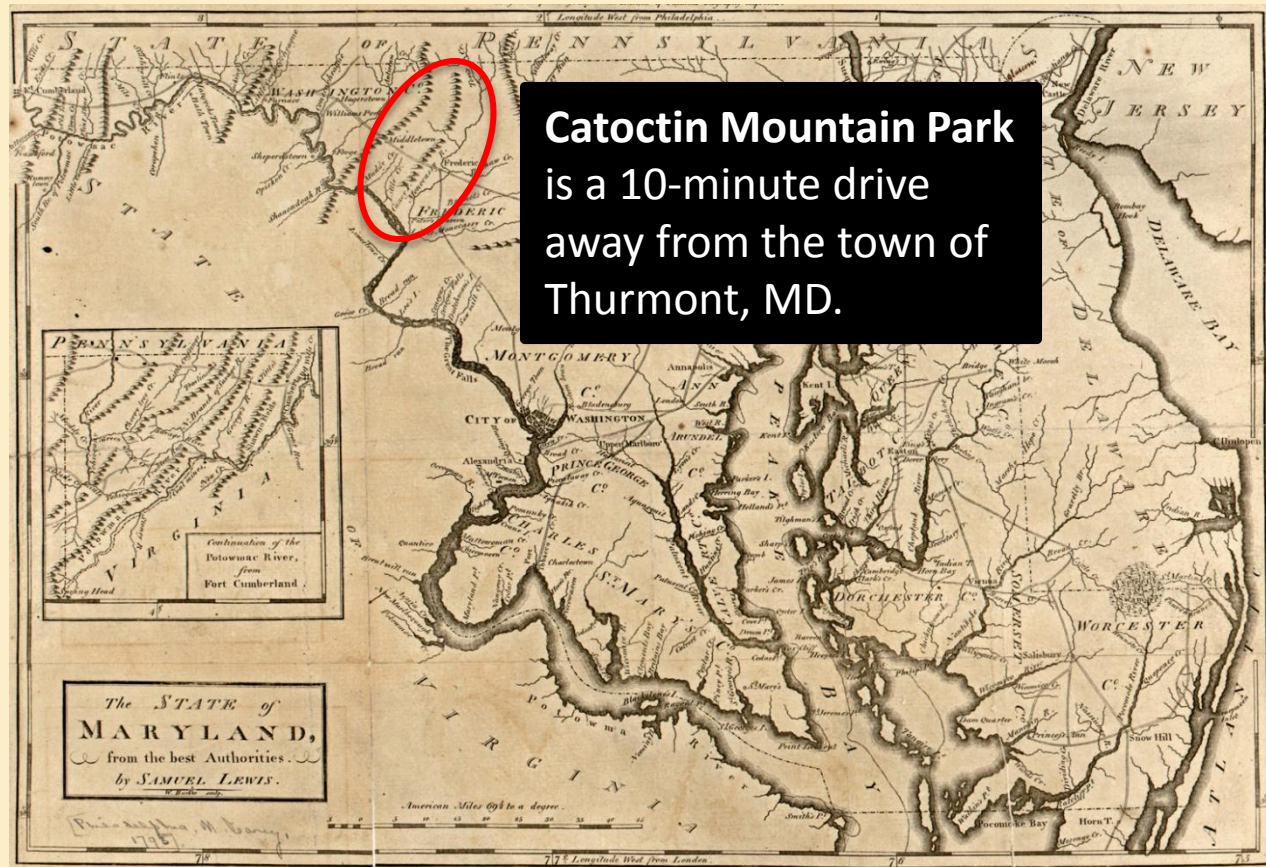


## About Catoctin Mountain Park

Catoctin Mountain Park is located in central Maryland, about an hour and a half north of Washington, D.C., and about an hour west of Baltimore. Most parts of the park, which covers 5,810 acres, are connected by 25 miles of trails.

The Catoctin forest, a Mid-latitude deciduous forest, is habitat to more than 280 species of animals and 750 species of vascular plants (including 60 species of trees).

Visitors often see are squirrels, chipmunks, white-tailed deer, pileated woodpeckers, box turtles, rattlesnakes, and very rarely, bobcats and black bears.



Brook trout (*Salvelinus fontinalis*)



Millipede (*Nerceus* sp.)



American black bear (*Ursus americanus*)



Eastern gray tree frog (*Hyla versicolor*)

## European Colonization & Settlement

European settlers began to arrive in Maryland in the 1630s, and their interactions with the indigenous societies in the area were shaped by pre-existing intertribal tensions.

- Some tribes, such as the Chesapeake Algonquian tribe, allied themselves with European settlers against rival tribes, such as the Susquehanna tribe.
- In these alliances, Native Americans exchanged knowledge of weapons, agricultural technology and natural resources.
- Eventually, European settlers dissolved their relationships with Native Americans as they began to expand plantation operations and displace their former allies.

## Iron in the Catoctin Mountains

Hematite ore was discovered in the Catoctin Mountains in the 1770s by Thomas Johnson Jr., who would become Maryland's first governor.

Thomas Baker and Roger Johnson constructed the Catoctin Furnace (*left*) and started producing pig iron in 1776. Catoctin's forest was clear-cut for charcoal, and workers mined local limestone to use in the iron-making process.

The Furnace provided materials for Revolutionary War weapons, and iron for the paneling on the *Monitor*, the famed Civil War vessel.

The Catoctin Furnace stopped operating in 1903, and mining for iron ore ceased several years later.

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HABS



## WPA, CCC and a “New Deal”

Catoctin Recreation Demonstration was established on January 7, 1935, as part of Franklin D. Roosevelt’s “New Deal” legislation. The park was transferred to the National Park Service in November 14, 1936.

The Works Progress Administration—part of the New Deal—initiated park restoration efforts. WPA workers built many of the historic structures in the park, including the Project Headquarters, which currently houses the park’s resource management department.

The Civilian Conservation Corps started rebuilding camps, planting native trees, rehabilitated fields and old logging roads, created the park’s water system, and installed dry stone walls on April 1, 1939. The park was renamed on July 12, 1954.

**Right:** CCC workers clearing trees in the Catoctin Recreational Demonstration Area forest.



**Left:** Girl Scouts and park superintendent Frank Mentzer at Camp Misty Mount in 1968.

# Lithology

*How does the region's lithology affect the park's hydrology and ecology?*



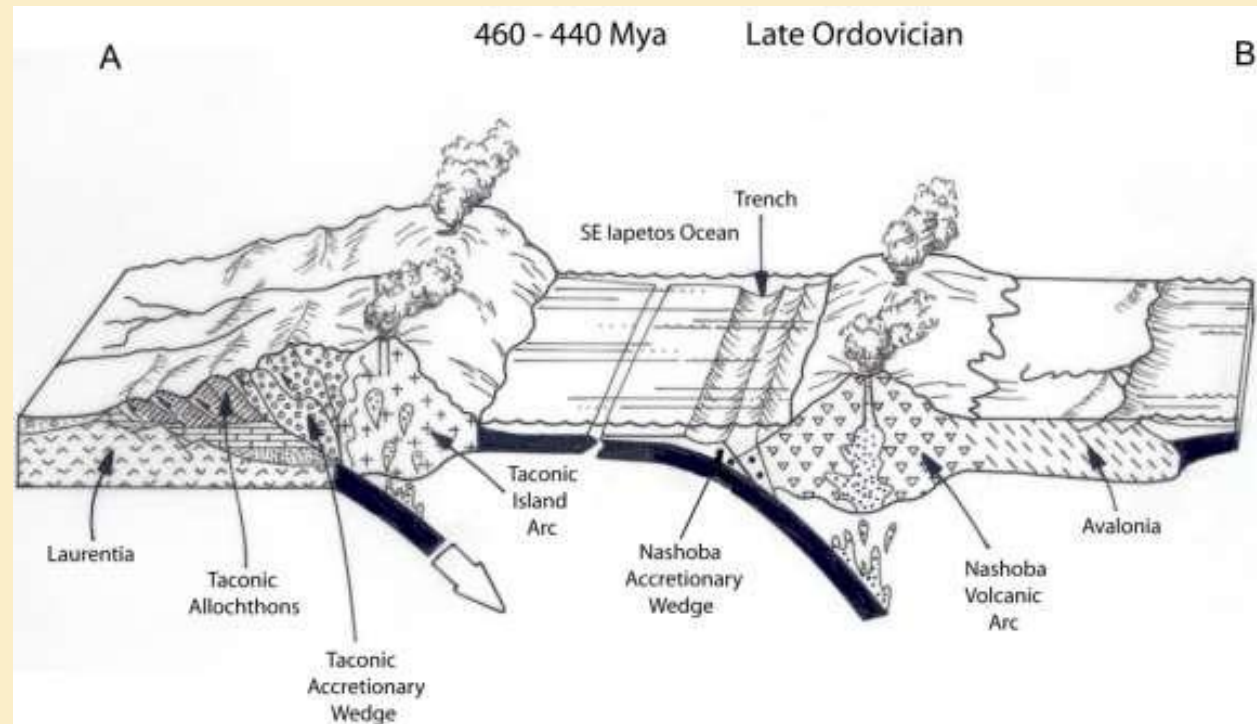
# Geologic Setting

The region was compressed during three periods of tectonic activity, or **orogenies**:

- **Taconic:** middle-late Ordovician (435-470 MYA)  
Thrusting and folding was mainly in the northern portion, uplifted mountains shed sediment to the west.
- **Acadian:** middle-late Devonian (340-370 MYA)  
Major orogeny of the northern Appalachians occurred in the Devonian, center in New England and southern New York. Strong folding, thrusting, metamorphism and granite intrusion took place.
- **Alleghanian:** early Pennsylvanian - Permian (250-320 MYA) Last major orogeny of the southern Appalachians. Marked by creation of Pangaea (late Paleozoic) which was a result of the collision of Gondwana and Larussia.

## Taconic 460-440 MYA

The metamorphosed accretionary wedge sediments and volcanic rocks of the Taconic Island Arc that were involved in this “collision” (Taconic Orogeny) now form much of western Connecticut.



# Silurian 440 Mya


(Modified from Scolese 2001)



 Taconic Orogeny

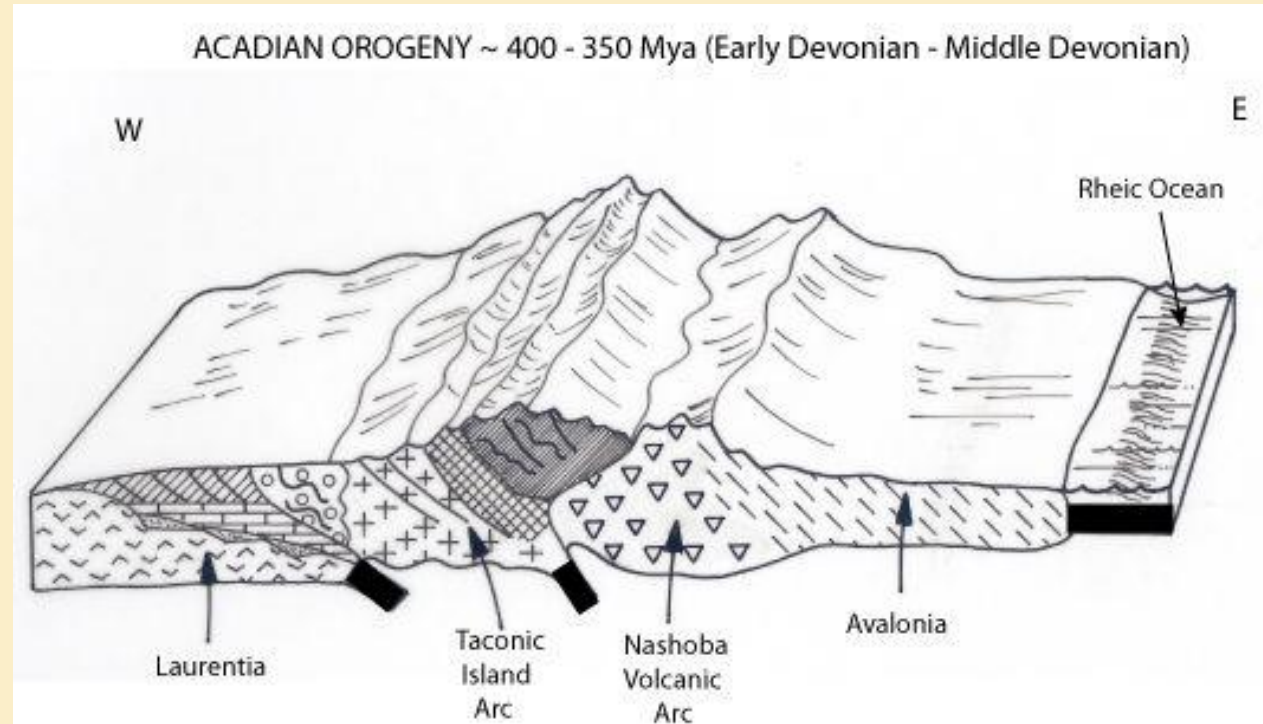
 Sea-floor spreading ridge

 Subduction zone

 Location of Maryland

## Acadian Orogeny 440-350 MYA

The Taconic Mountains were eroded as southeastern Iapetus Ocean closed. The Nashoba Island Arc and the small continent of Avalonia, which had rifted from Gondwana as the Rheic Ocean formed, were sutured to the eastern margin of Laurentia during the Acadian Orogeny.

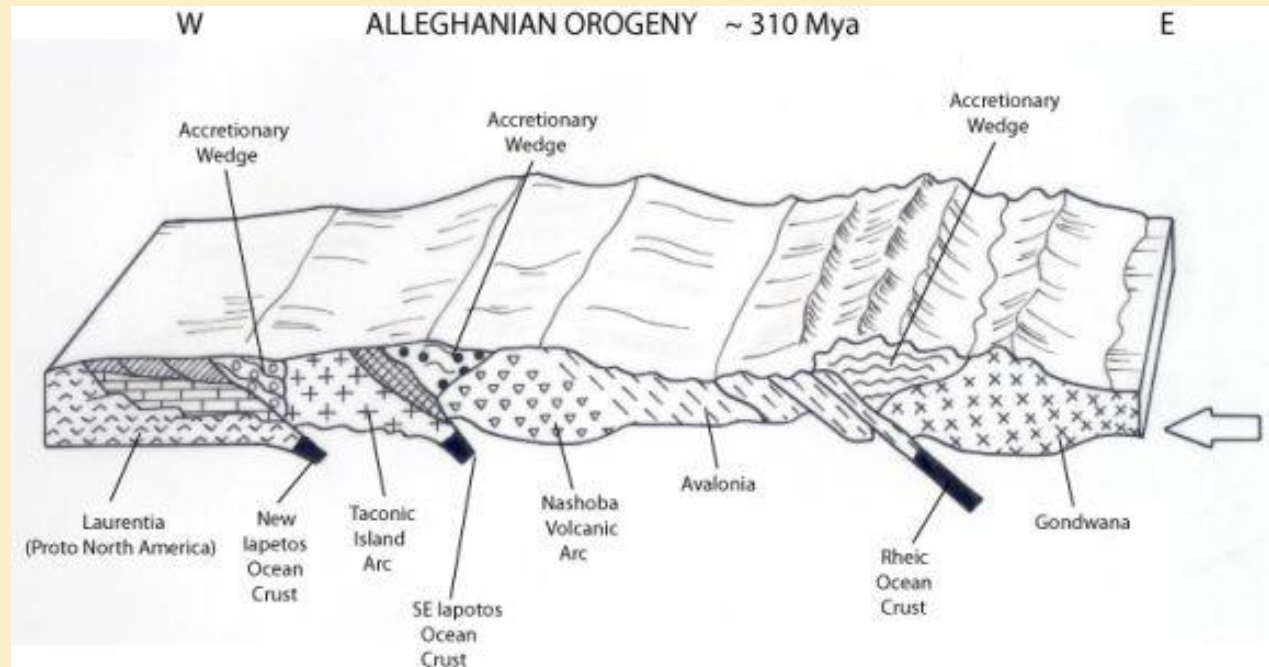


## Early Devonian 400 Mya - ACADIAN OROGENY

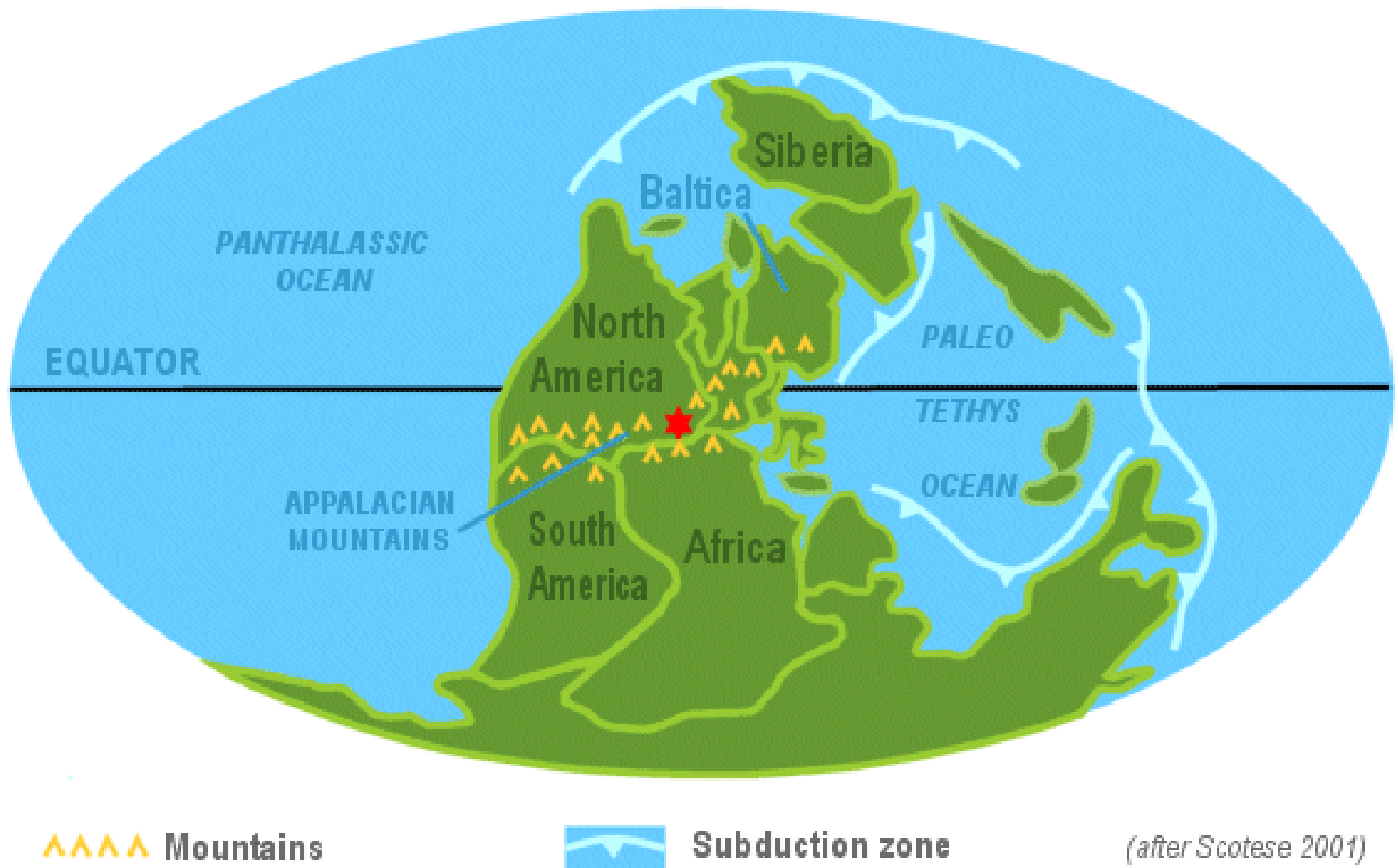


## Alleghenian Orogeny 350-270 MYA

The Acadian Mountains were eroded as the Rheic Ocean closed, and the “African” portion of Gondwana collided with the accreted eastern margin of Laurentia. This collision played a major role in the assembly of the supercontinent of Pangaea, and completed the “collision phase” of the geologic history of eastern North America with the creation of the Appalachian mountains.



## Alleghenian Orogeny 300 Mya - Formation of Pangaea



# Geologic Setting

Catoctin Mountain Park is located along the ridge that forms the boundary between the Blue Ridge and Piedmont physiographic provinces.

The rock in the park area reflects the Appalachians' tectonic history. This period of tectonism culminated in the formation of the Blue Ridge – South Mountain anticlinorium. Catoctin Mountain is on the eastern limb of this large regional fold.

Precambrian gneisses and other metamorphic rocks and Paleozoic quartzites and phyllites are common throughout the park.

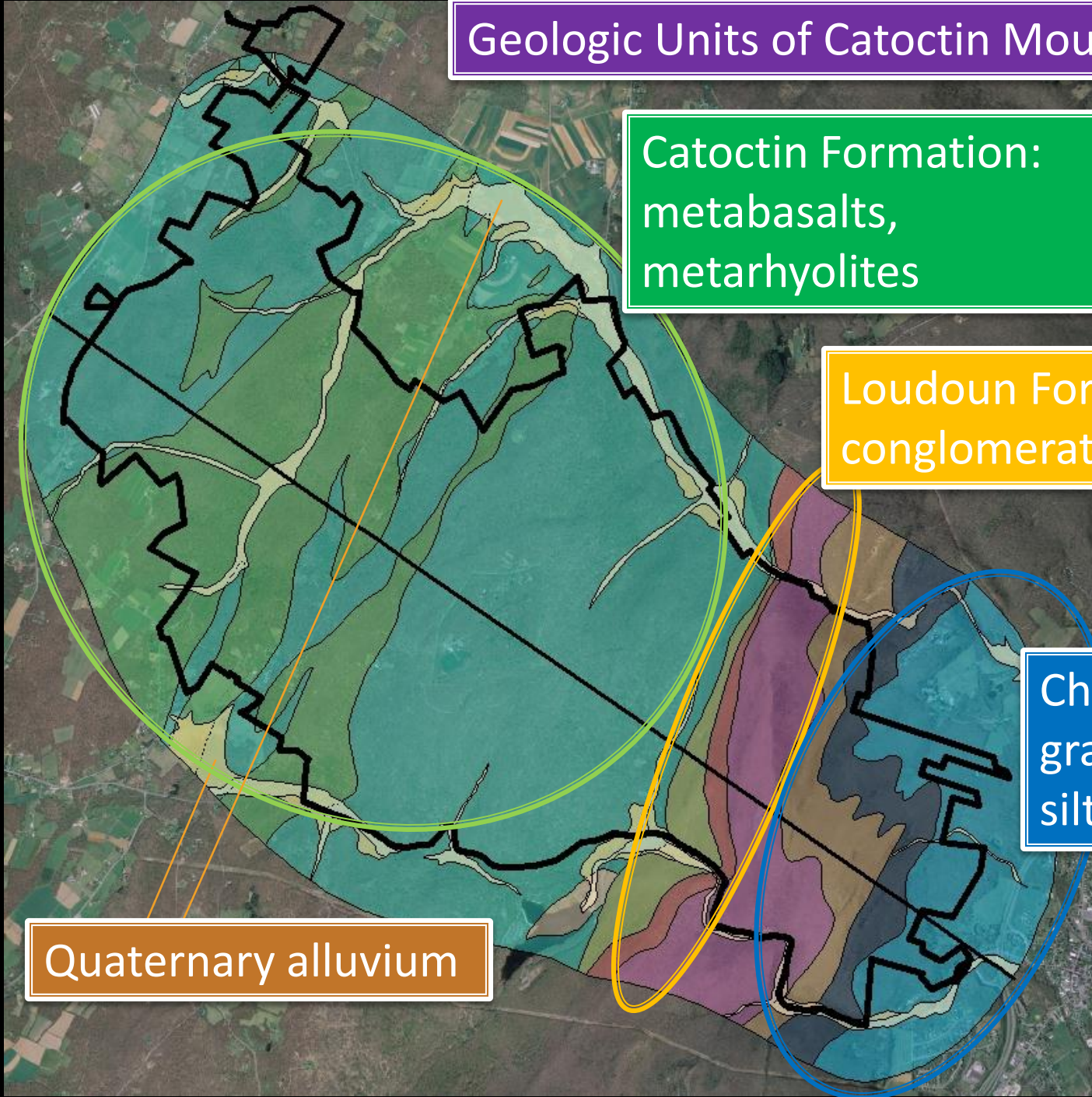
# Geologic Units of Catoctin Mountain Park

Catoctin Formation:  
metabasalts,  
metarhyolites

Loudoun Formation:  
conglomerates, phyllites

Chilhowee Group:  
graystone,  
siltstone, arkose

Quaternary alluvium



## Lithology and Water Quality

*The geochemistry of the park's streams is affected by both non-natural sources (e.g. pollution, sediment resulting from human activities) and natural sources (e.g. lithology).*

*Natural changes in water that reflect underlying lithology result from hydrolysis -- the process that controls the chemical composition of most natural waters -- and weathering.*

- At the crest of Catoctin mountain, creeks flowing through lithologic units of quartzite and phyllite near the crest of the mountain contain higher ratios of **Na : Ca** and **Na : Mg**, which is consistent with the felsic composition of these rocks
- Thinner, saprolitic (clay-rich) soils also affect water chemistry

# Wetlands & Watersheds

*What is a wetland? What is a watershed? What is the relationship between the two?*



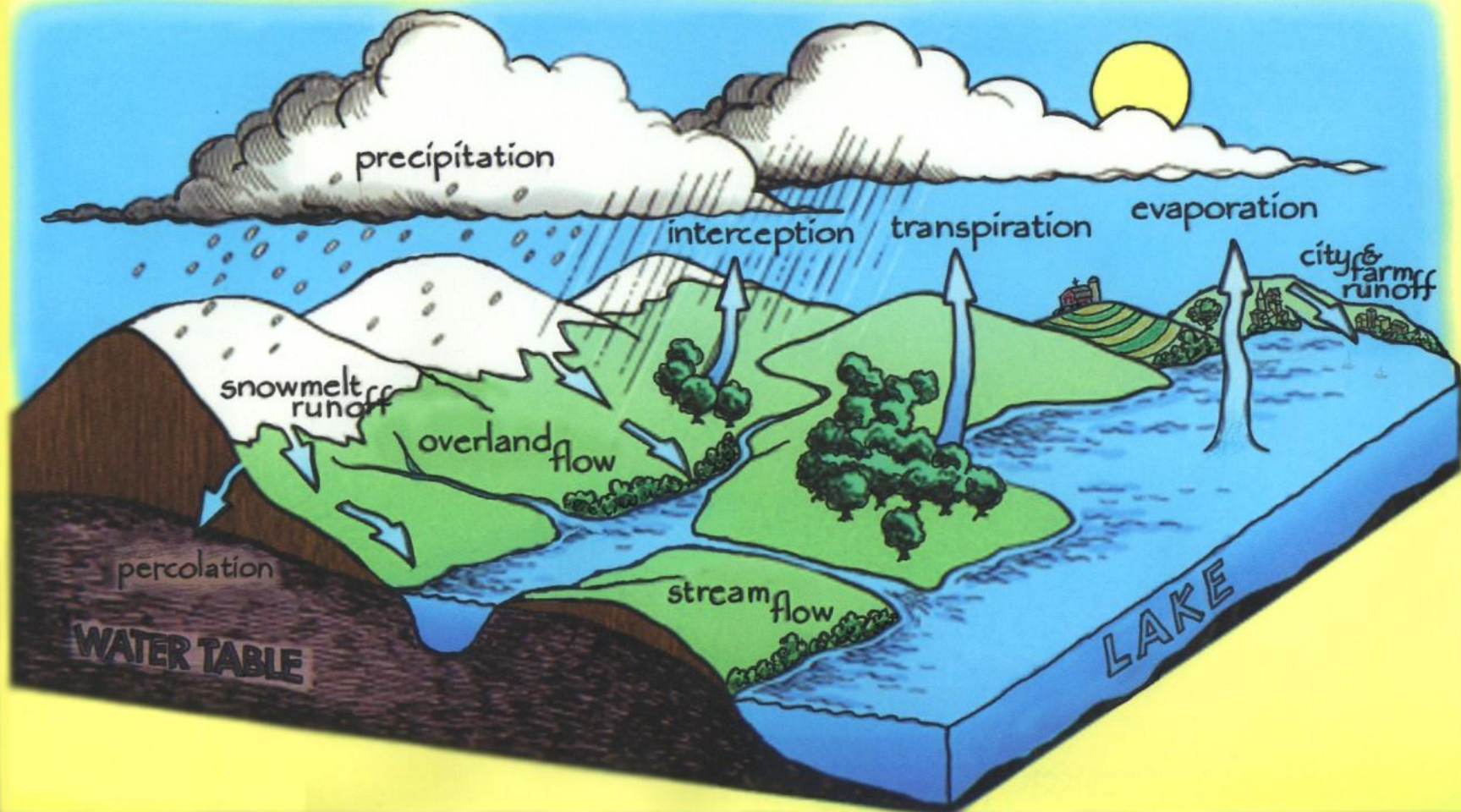
# What is a watershed?

*“that area of land, a bounded hydrologic system, within which **all living things are inextricably linked by their common water course** and where, as humans settled, simple logic demanded that they become part of a community.”*

-- John Wesley Powell, scientist and geographer

# What is a watershed?

- A watershed encompasses all of the streams, rivers and creeks in an area that drain into a single body of water (e.g. a lake, river or creek).
- The park lies within the Upper Monocacy watershed, but no watersheds lie completely within the boundaries of the park.



# Watersheds in the Park

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Several streams along Catoctin Mountain—including Big Hunting Creek and Hauver Branch—have been studied in order to understand the effect of acid rain-related weathering in the United States

Park watersheds are unspoiled but susceptible to impacts from suburban development

# What is a wetland?

Wetlands are water-saturated areas that contain:

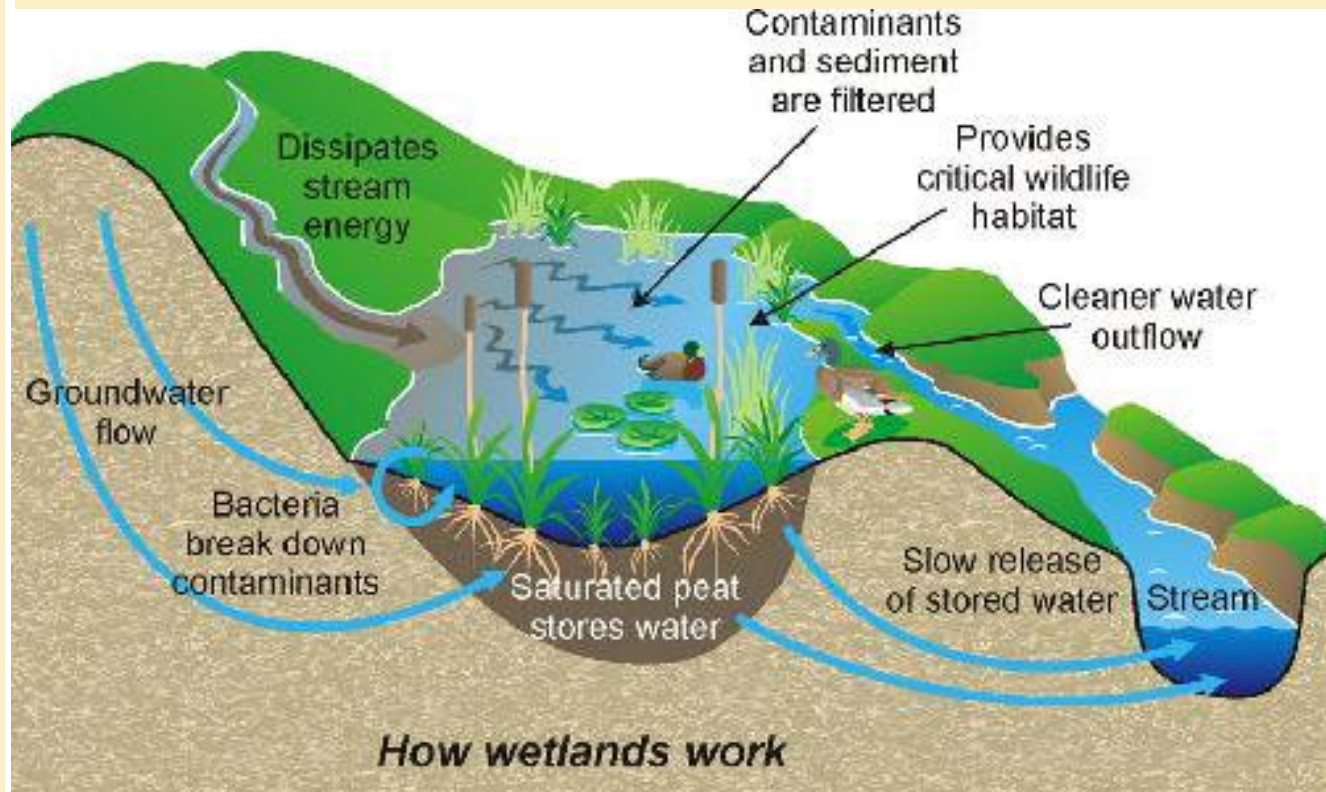
- **hydric soils** (soils that are saturated with water for at least 1-2 weeks out of the year)
- more than 50% of its total vegetation designated as wetland plants
- hydrological indicators, such as drift lines, flow patterns, flood-related debris, muddy substrate, etc.

**18 designated forested wetland areas cover 143 acres of Catoctin Mountain Park.**

## What is a wetland?

Wetlands offer many ecosystem services, including:

- Wildlife habitat
- Assistance with flood and erosion control
- Groundwater recharge/stream flow
- Filtration of sediment that is damaging to ecosystems
- Filtration of nutrients (e.g. nitrates, phosphates) that may otherwise cause eutrophication



# How are wetlands formed?

Wetlands are usually formed in:

- depressions (natural or man-made)
- along the shores of water bodies
- on broad flats with poor drainage
- at the bottom of slopes
- they may be formed on the slopes themselves if fed by groundwater springs/surface water drainageways

## Wetlands in Catoctin Mountain Park

*Wetland near Owens Creek.*

*This wetland was formed after a portion of the creek was dammed and used to float logs to a nearby sawmill the 1800s.*



# Native wetland plants in Catoctin Mountain Park



**Eastern skunk cabbage**  
(*Symplocarpus foetidus*) is used for wetland delineation because it only grows in soils that are hydric for most of the year.

*S. foetidus* exhibits **thermogenesis**: it can heat itself 15-95°F above air temperature in order to melt snow and attract pollinating flies that are drawn to the plant's warmth and pungent odor.

# Hydric soils & hydrological indicators

Common field indicators of hydric (water-saturated) soils include:

- **Organic soils (histosols):** thick peats and mucks
- **Organic surface layers :** organic layer that forms above the mineral substrate
- **Sulfic material:** soils that emit rotten egg order
- **Iron/manganese concentrations:** accumulations of black or dark brown masses
- **Soil color:** gleyed (greenish, bluish, greyish) or low chroma (dull) / mottled soils (bright splotches of color in a dull matrix)
- **Dark vertical streaking:** cross-sectional view of the soil in a soil put will appear to be vertically streaked

# Data & Results

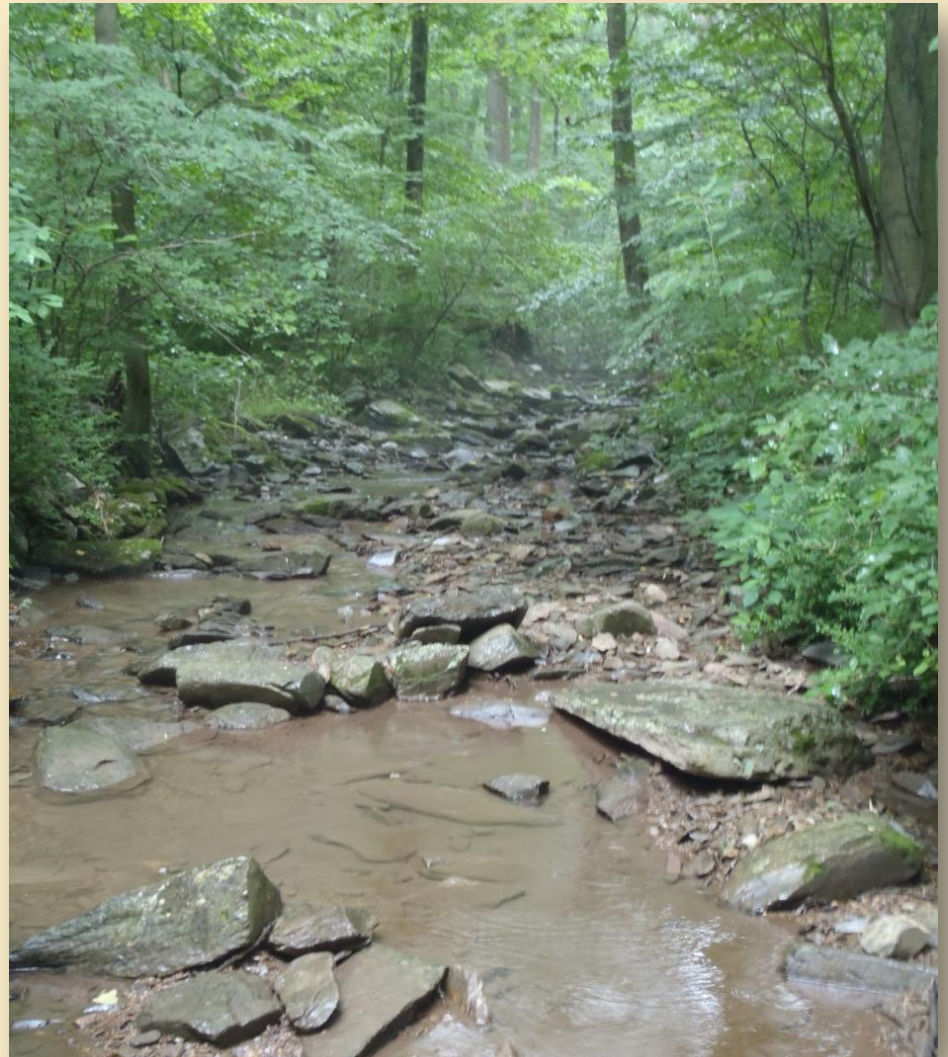
*Which areas were mapped?*



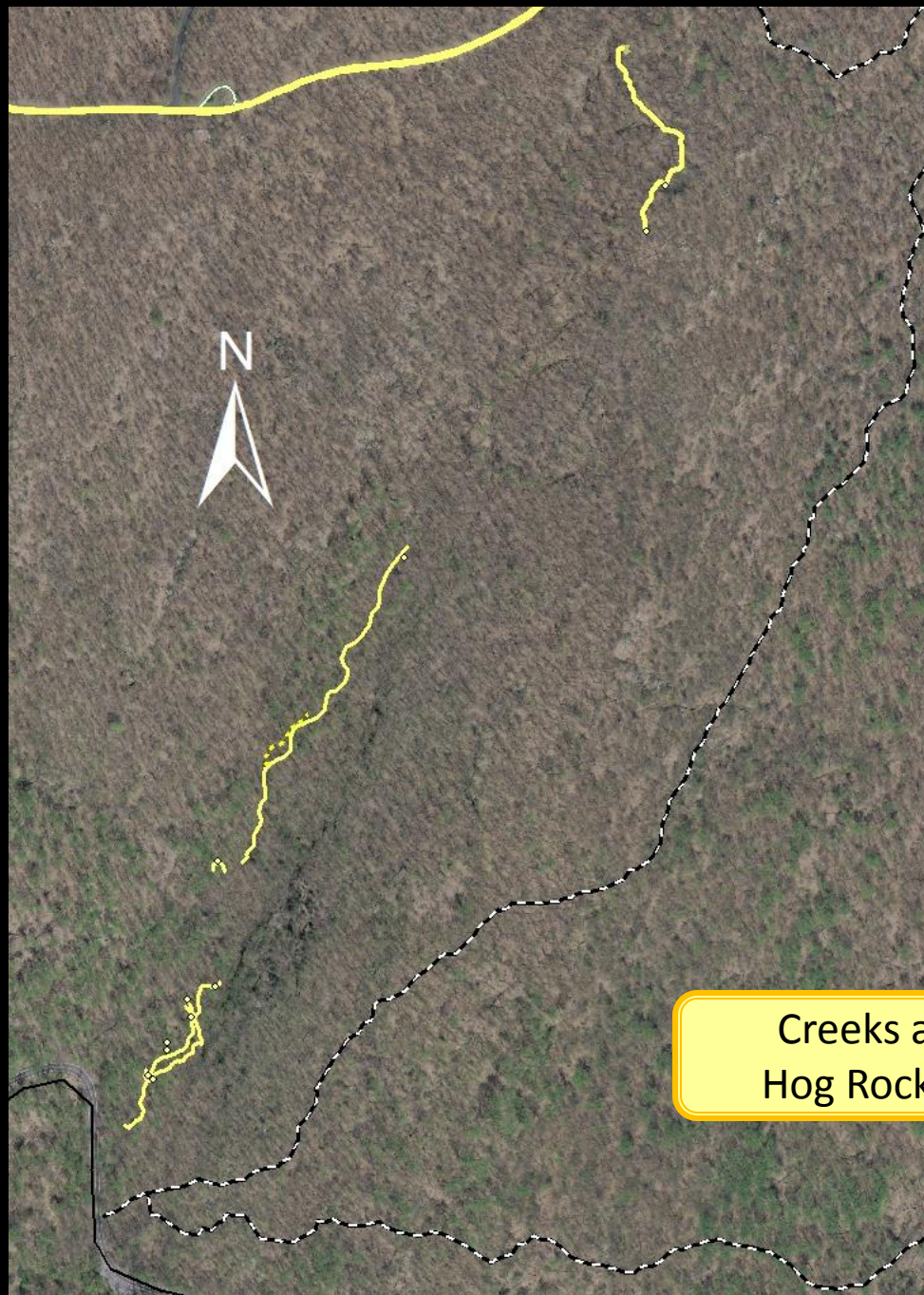
## Data & Results

My survey of Catoctin Mountain Park's streams and wetlands focused on four regions:

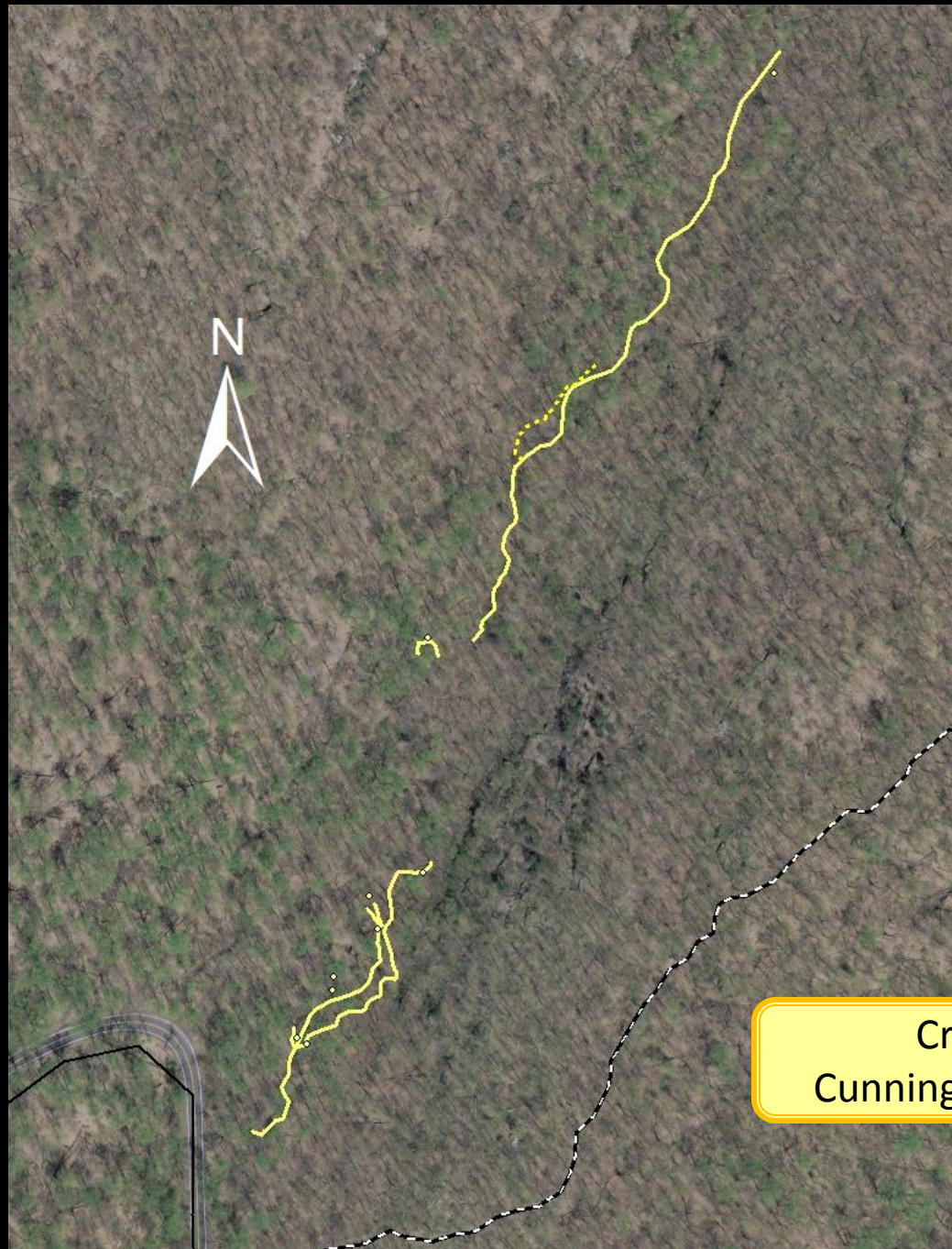
- Cunningham Falls/Hog Rock
- Ike Smith
- Misty Mount/Blue Blazes
- Owens Creek (headwaters)



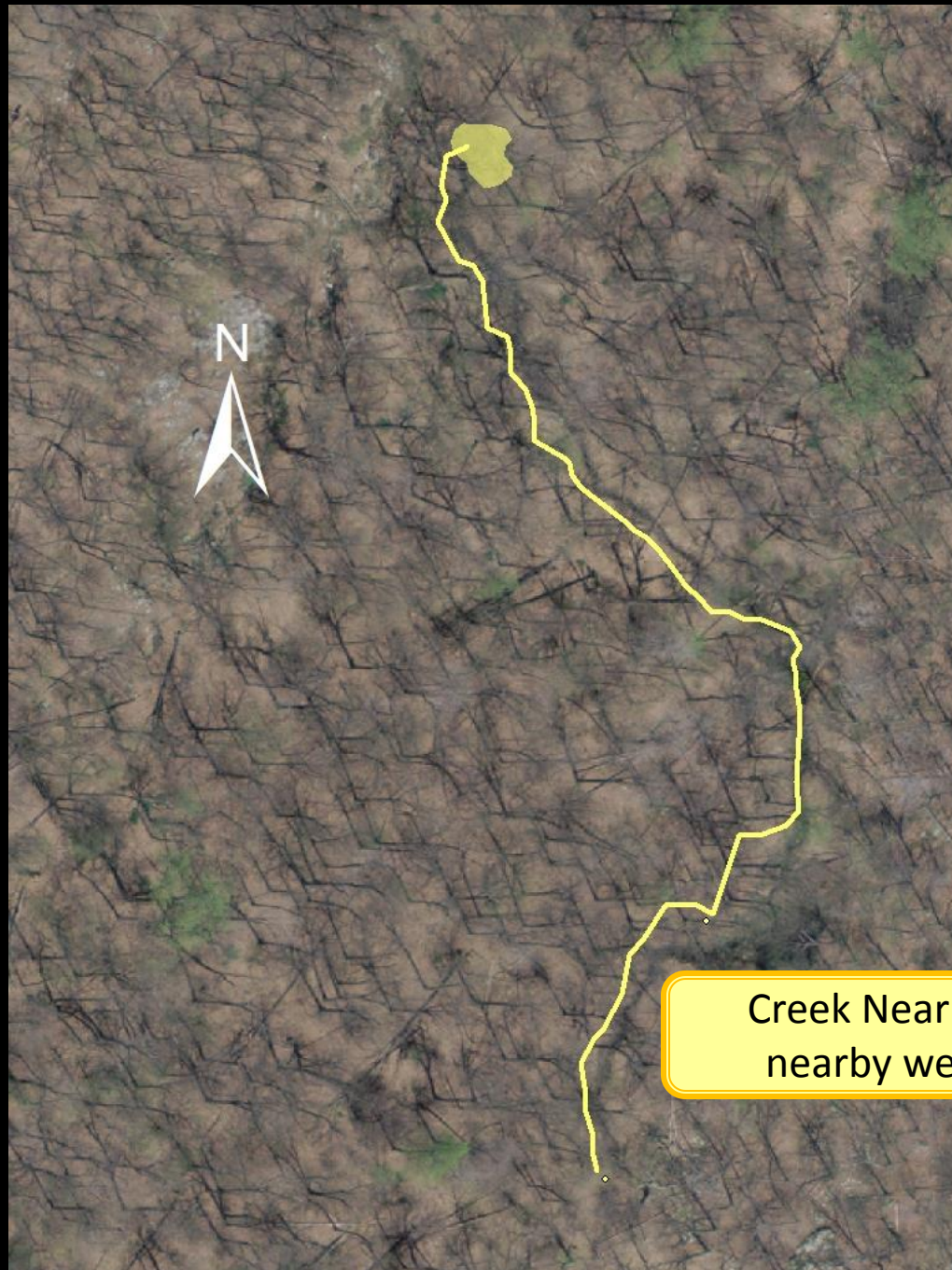
*An upstream  
view of Owens  
Creek.*



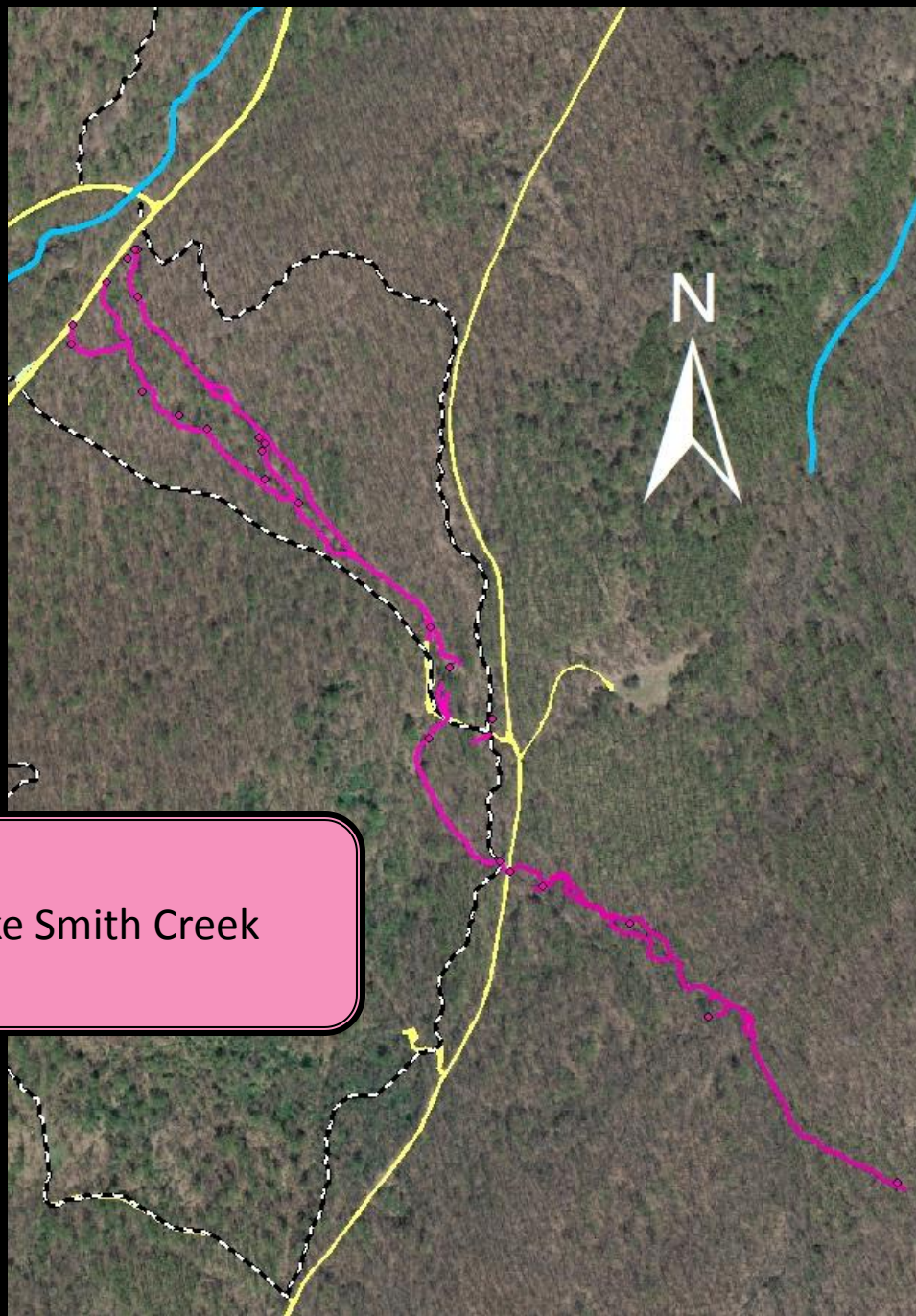
Creeks and Wetlands near  
Hog Rock/Cunningham Falls



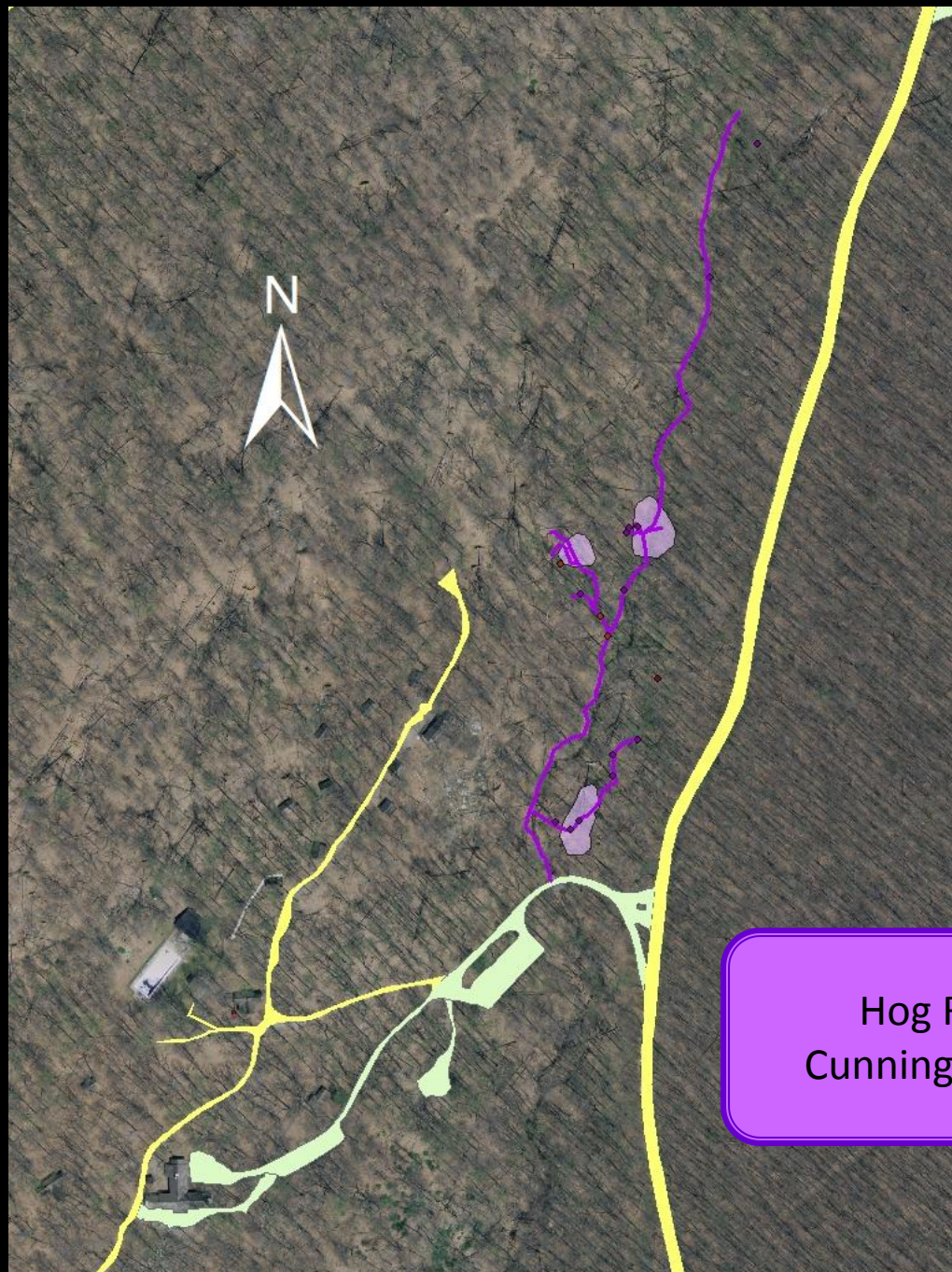
Creek near  
Cunningham Falls Trail



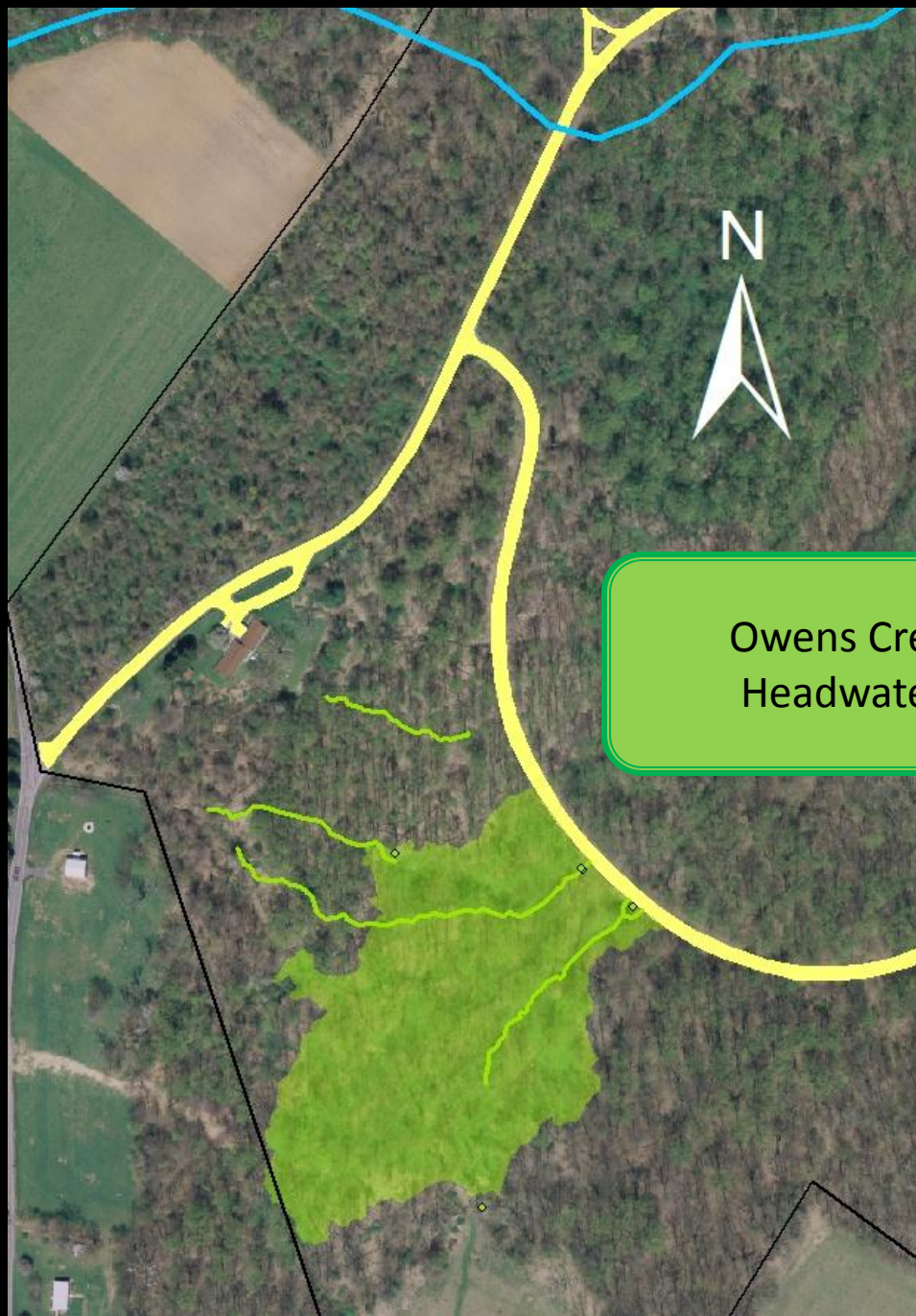
Creek Near Hog Rock Trail & nearby wetland enclosure



Ike Smith Creek



Hog Rock &  
Cunningham Falls



Owens Creek  
Headwaters

# Applications

*How will this data be used in future park projects?*



# Applications

Mapping streams and wetlands expands our understanding of:

- Regional water quality
- Biological surveys, esp. of threatened plants
- Impact of recreational use on ecosystems
- Impact of hazardous waste spills
- Effects of land use adjacent to/within park
- Geologic hazards (e.g. mass wasting)

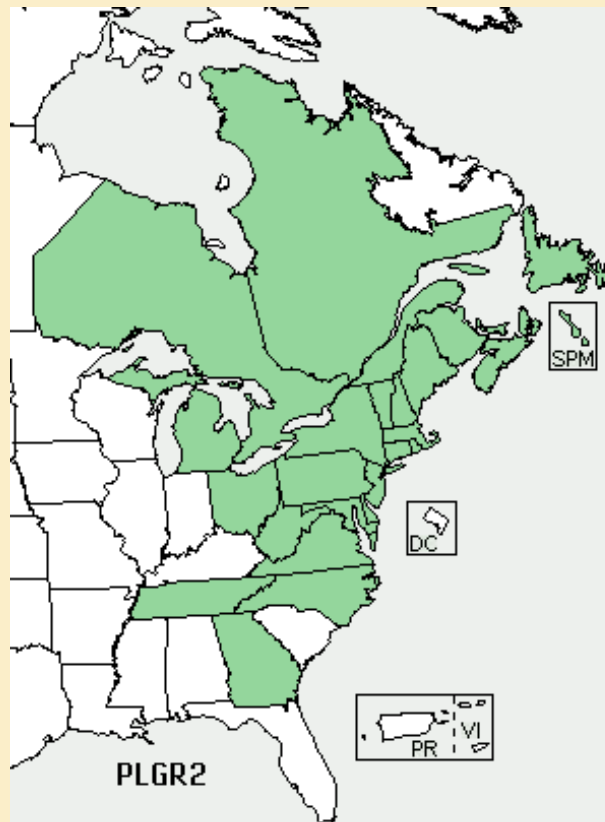
## Purple-Fringed Orchids

Greater purple-fringed orchids depend on symbiotic relationships that allow the plants to absorb essential nutrients from forest soils. These orchids primarily grow along the edges of shaded wetland areas.

These orchids have been designated as a 'threatened' species in the state of Maryland, and park staff count and map these flowers, which typically bloom at the beginning of the summer.

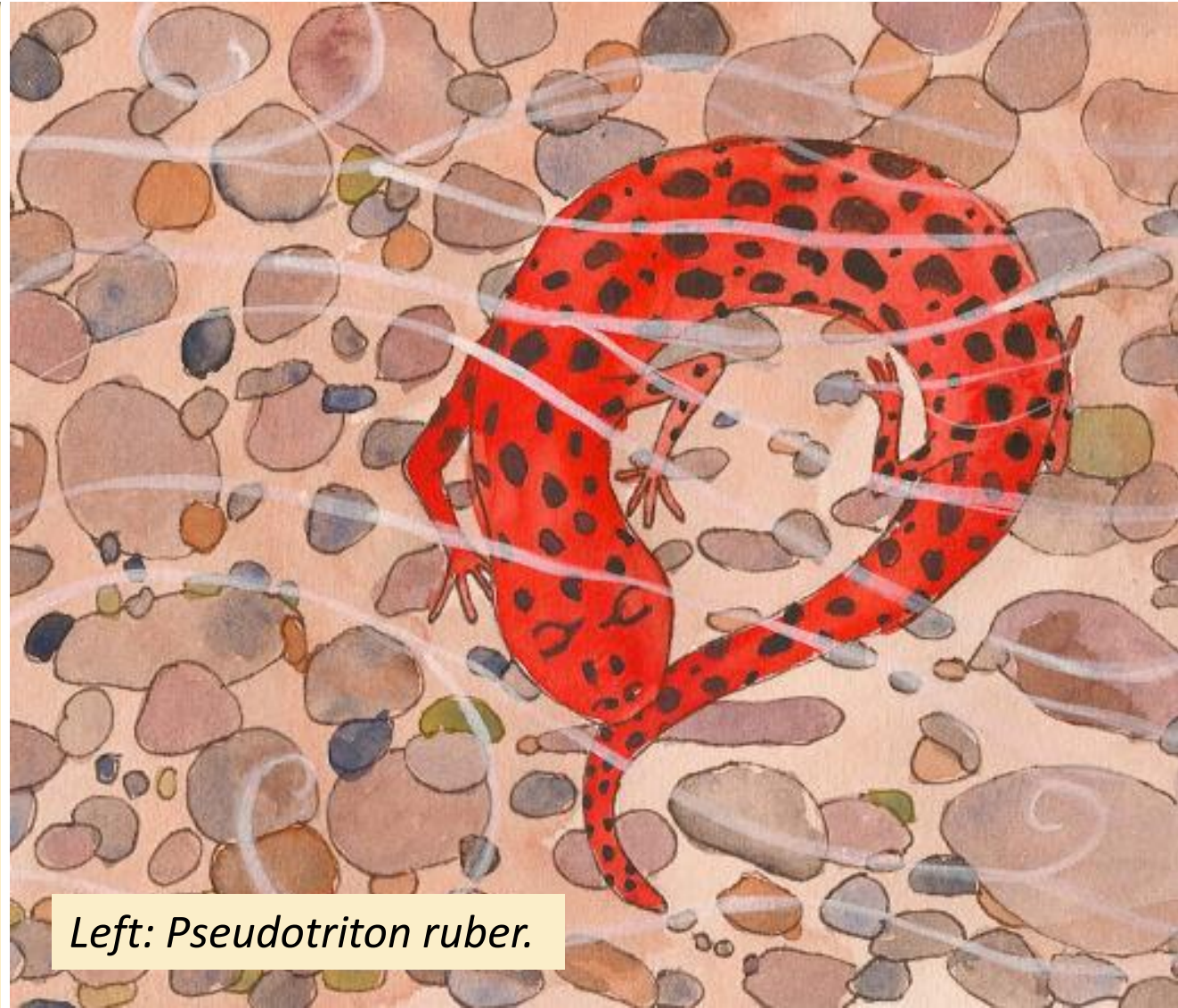
**Right:** Greater purple-fringed orchids (*Plantanthera grandiflora*).

**Bottom:** Range of greater purple-fringed orchids.



## Amphibians: canaries in a coal mine?

Amphibians are considered good indicators of general ecosystem health because of their close association with various aquatic habitats: they are sensitive to different environmental stresses and disturbances.



*Left: Pseudotriton ruber.*

## Amphibians: canaries in a coal mine?

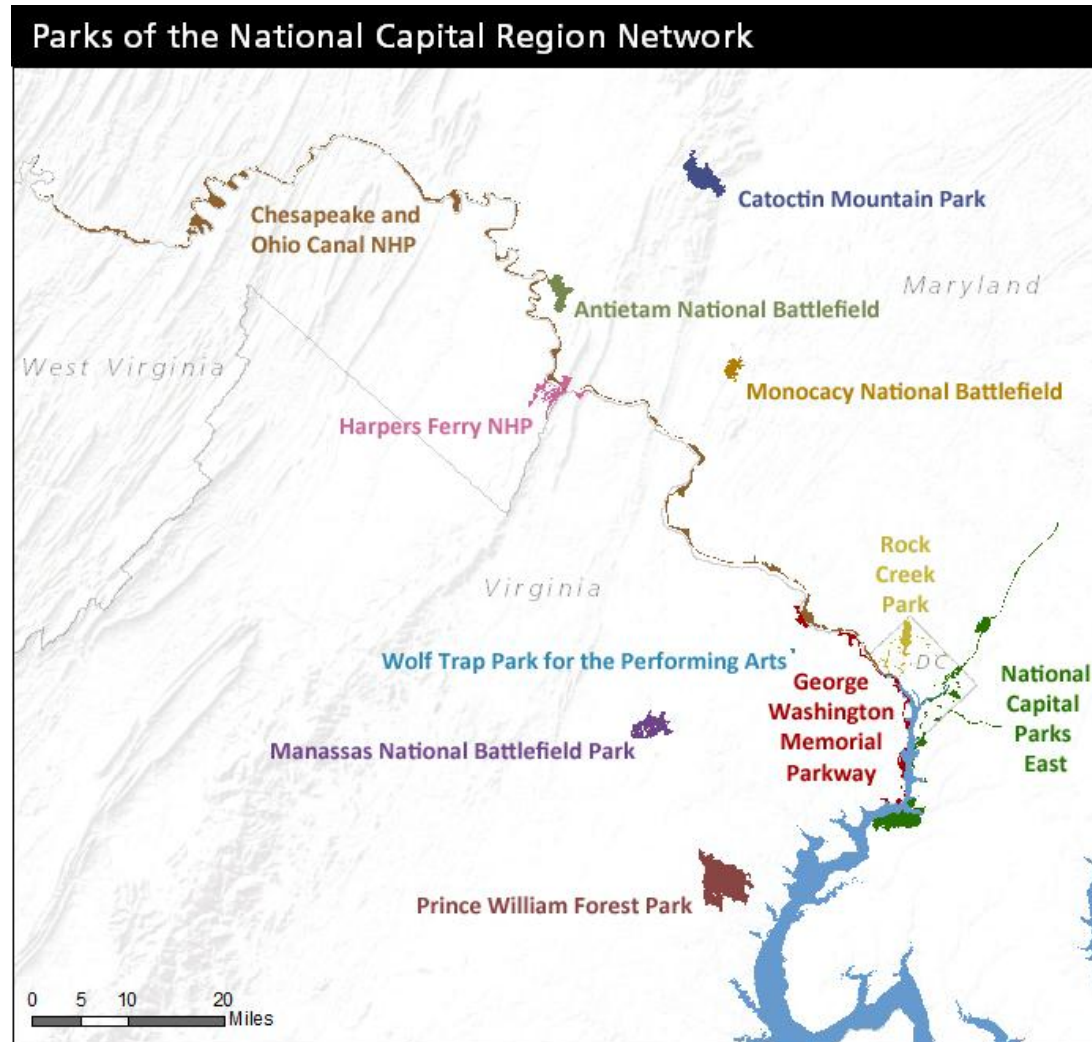
Very little is known about the effects of deforestation, highway construction, urban development, and other potential stressors, such as:

- contaminants
- introduced species
- climate change
- UV radiation
- disease
- atmospheric deposition



# Amphibians: canaries in a coal mine?

- In 1998, an international meeting of herpetologists convened by the National Science Foundation concluded that the significant amphibian declines have been observed in protected areas (national parks, wildlife refuges, and wilderness areas) should be treated as an environmental crisis.
- Congress initiated funding for the DOI begin to monitor amphibians on public lands starting in 2000.
- Parks in the National Capital Region Network (left) began monitoring amphibians in 2005 to determine to current distribution and status of amphibian populations.



# Questions?

